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A CHRONOLOGICAL REVIEW OF DEVELOPMENTS IN PHYSICAL SCIENCE DURING THE PERIOD OF WORLD WAR II (CHEMICAL AND BIOLOGICAL DEVELOPMENTS ARE EXCLUDED)

by

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June, 1942)

submitted in partial fulfillment of the
requirements for the degree of
Master of Education
June, 1949

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CHAPTER I

THE PROBLEM

INTRODUCTION

The ability to solve problems in everyday life is considered the main objective or outcome of science education. Science teachers in elementary and secondary schools are not and should not be attempting to train specialists. Their main purpose is to provide sufficient and varied learning experiences so that the students will have a fund of knowledge on which to base future behavior in problematic situations. Of course it is impossible for the teacher to provide factual experiences to cover every conceivable future situation. He can and should, nevertheless, teach for a functional understanding of the basic generalizations or principles involved in scientific phenomena. He should also provide sufficient thought-provoking situations so as to develop a mode of attack which is generally called the scientific method.

The Educational Policies Commission of the National Education Association[1] states the aims of the teaching of science as follows:

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[1] Educational Policies Commission, Education For All American Youth. Washington: National Education Association, 1944.

1. An educated person will understand that science is based upon methods, which man has slowly and painstakingly developed, for discovering , verifying, organizing, and interpreting the facts about the world in which we live and about the people in it.

2. He will know that the use of scientific methods has worked revolutionary changes in men's ways of living and thinking.

3. He will know that most scientific advances have depended upon precise measurement and accurate calculation and that mathematics is indispensible to scientific inquiry.

4. He will recognize that problems in human society, as well as in the physical world, should be attacked by scientific methods and from a scientific point of view.

5. He will be familiar with certain fundamental principles and facts from the sciences, which, when taken together, give him a sound view of the nature of the world in which he lives.[1]

The elements of the scientific method are not a cut and dried technique. Many authors list steps and procedures for purposive reasoning. The example which follows is that of Read[2], parts of which are from other sources.

The sequence of scientific method:

1. Accurate observation of phenomena

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[1] Ibid., 133.

[2] Read, John G., "The Physical Sciences-1949", Unpublished teaching material. Boston University School of Education, 1949.

2. Formulation of hypothesis

3. Testing of hypothesis by experiments

4. Statement of theory (a clarified hypothesis)

5. Further testing by means of varied, repeated, new experiments including those done by many individuals

6. If every result over a reasonable time fits the theory, a "law" may be worded.

7. Classification under "laws" of all new facts; and repeated testing by experiment. There is no "law" of physical science which is not subject to change if facts are found which make it false.[1]

It is evident that a knowledge of the underlying principles concerned with the scientific facts and phenomena taught is one of the main steps in the reasoning pattern. Here is a suggested technique which teachers can use to help the student visualize the principle in every-day use and not as something to be learned for the science test and then forgotten. The teachers can utilize the commonplace familiar scientific paraphenalia and also new scientific inventions and developments as living examples of the principles involved. Practically every scientific "gadget", no matter how intricate and complicated, can be reduced to basic principles. If the teacher is trying to build up an understanding of a principle, he or she can relate it to a new scientific

[1] Ibid., 1.

phenomenon (if the information is available). The newness, if nothing else, would motiviate the student and provide interest. It would be meaningful and of more immediate value than the historical outdated examples. A tie-in experience for the student would be for him to be given the bibliographical sources of these new scientific developments and be allowed to look-up, read, and study about them himself.

STATEMENT OF PROBLEM

The problem of this paper is to survey the popular scientific periodicals for the period of World War II and to list the developments that are concerned with principles of physical science with bibliographical sources. (The principles of chemistry are excluded.)

JUSTIFICATION

The purpose of the study. This study was undertaken to provide science educators with a single comprehensive list of the important scientific developments during a certain period of history to use as a reference, bibliographical, or teaching aid. Conant[1] states that "there must be constant critical appraisal of the progress of science ...". This study is an attempt, admittedly

[1]Conant, James B., On Understanding Science. New Haven: Yale University Press, 1947. 13.

small, at appraisal.

Stimulus of the war emergency. This particular period was chosen to be reviewed on the assumption that it would contain a greater number of developments in the field of science than during other similar periods of time due to the added stimulus of the war emergency. Whether or not this assumption is correct depends on the meaning of developments. On this point the writer takes the view similar to Fosdick[1] who states:

> There is a popular belief that science made rapid progress between 1939 and 1945, but this belief has little basis for support. It is now generally recognized that the feverish activities of scientists during wartime are essentially not scientific. They are primarily engaged in the application of existing knowledge to certain specific and narrow problems, they have not time for pure research, and their contributions to basic knowledge are infrequent and on the whole unimportant. They are using up the supplies of basic discoveries which an earlier generation has given.[2]

Osgood[3] states along the same line:

> The atomic bomb is, in itself, not a discovery, but rather an engineering development of earlier discoveries of physics. Every few years since 1895 some important discovery in atomic physics has been made,

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[1]Fosdick, R. B., Report of the Rockefeller Foundation. New York: The Rockefeller Foundation, 1946.

[2]Ibid., 25.

[3]Osgood, Thomas H., "Physics", American Year Book. New York: Thomas Nelson and Sons, 1945.

> each one a triumph of the human intellect. It is the sum total of these discoveries, including that of uranium fission in 1939, which made possible the development of the atomic bomb. [1]

For the purpose of this study, a development will be arbitrarily defined as a new technique, process, or refinement based on one or more principles of physical science (exclusive of chemistry).

Objective of general education. The American Council on Education[2], The National Education Association[4], and the National Society for the Study of Education[3] agree that the comprehension of the physical science phenomena and scientific advances is one of the major objectives of general education. The science educators have a definite need for a singular source of information concerning

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[1] Ibid., 825.

[2] A Design of General Education, Series I, Reports of Committees and Conferences, Number 18. Washington: American Council on Education, 1944, 183.

[3] Science Education in American Schools, Forty-Sixth Yearbook of the National Society for the Study of Education, Part I. Chicago: University of Chicago Press, 1947, 25..

[4] Education for All American Youth, op cit., 153.

the recent wartime advances. As Powers[1] states, "Science moves so fast these days that the scientific specialist cannot keep up completely even in his own field, much less a secondary school teacher who must have a wider field of interest in more general areas".

SCOPE

Principles of physical science. As previously mentioned, this paper deals with developments based on principles of physical science excluding chemistry. The lists of principles of physical science formulated by Wise[2] are accepted as part of the criteria for the selection of developments. The field of chemistry is excluded in an attempt to limit the breadth and length of the paper.

There is a trend in education to require all students, scientific and non-scientific, college and non-college preparatory, to take a course in physical science.

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[1] Powers, Philip N., and Stickler, W. Hugh, "Why Not Courses on Recent Developments in Science?", School Science and Mathematics, XLVI (Dec., 1946) 814.

[2] Wise, Harold E., "A Determination of the Relative Importance of Principles of Physical Science for General Education". Unpublished Doctor's dissertation, University of Michigan, 1941. See Science Education, XXV (Dec., 1941) 371-379; XXVI (Jan., 1942) 8-12; XXVII (Feb., 1942) 36-40; XXVII (Sept.-Oct., 1943) 67-78.

The Harvard Committee[1] states that the aims of the "fused" physical science course are primarily "those of general education, not the development of the skills and technical knowledge of the potential physicist and chemist". Since the aims of the course are those of general education, it should be an objective of the teacher to present only the latest information to the class. In order to do this, the teacher must keep up-to-date on scientific advancements and developments.

Source of technical information. The common source of the more or less technical scientific information to the general public, radio and newspapers, not to mention "fictional" periodicals and Comic Books, often produces a somewhat distorted if not completely false concept. A clarification, if only partial , by the educators in the science courses presupposes a current knowledge of scientific developments.

Persing[2] states that new developments in science and the scientific material appearing in popular publications should provide orientation in the development of science

[1]General Education in a Free Society, Harvard Committee Report. Cambridge: Harvard University Press, 1945.

[2]Persing, Ellis C., "Bringing Science Teaching Up To Date." Science Education, XXVIII (April, 1944), 158-159.

instruction. Science teachers, due to time limitations, are dependant in most part on the textbook used in the course, review courses, and review literature such as this paper. As far as review courses go, there have not been many offered on developments in science. Powers[1] states in regard to review courses:

> ... not a single graduate school in the United States offers coursework in recent developments in science designed to keep the secondary school science teacher up to date on recent happenings in science and thus to help him discharge his teaching responsibilities more effectively.[2]

The article advances the thesis that courses of this nature are much needed and that they would fill a useful purpose in science education.

Teachers of physical science courses as well as science educators in general should find a knowledge of developments in science indispensable. It not only tends to give the teacher confidence and produce more dynamic teaching but affects the learner also by increasing his interest, setting the stage for lively meaningful class sessions.

Pupils who are given access to a suitable type of written material read large quantities of scientific

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[1] Op. cit.

[2] Ibid., 811.

literature. This was pointed out by Curtis[1] and by Rice[2]. Both investigators also reported that extensive reading of general science materials contributed significantly to the scientific information possessed by pupils. In a study of pupils' opinions, Kutz[3] brought out the fact that students found newspapers helpful in keeping up with current health information. Many similar studies show results on the same plane.

A knowledge of developments in science plus a knowledge of their whereabouts in the literature will enable the science teacher to choose suitable books, newspapers, and periodicals to provide for outside reading and experiences for his pupils.

Method for teachers. This study offers a method for teachers for the discovery and use of applications of principles in their own subjects. These steps are offered:

1. Investigate and thoroughly study the generally

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[1]Curtis, Francis D., "Some Values Derived from Extensive Reading of General Science." Contributions to Education, Number 165. New York: Teachers College, Columbia University, 1924, 142.

[2]Rice, Ralph S., "Extensive Reading Versus Intensive Textbook Study as a Means of Acquiring a Knowledge of Scientific Facts." Journal of Experimental Education, IV, (June, 1936), 376-402.

[3]Kutz, Sally E., "The Newspaper as Source Material in Health Education." Unpublished Doctor's dissertation. New York University, 1952, 154.

accepted principles concerned with the topic or unit to be presented.

2. Discover, through library sources, periodicals whose contents would present the required applications of principles. The accepted principles must always be kept in mind.

3. Use these recent and significant applications of principles (as advocated by Persing[1] and Powers[2] and others) to provide interesting and varied learning experiences for the students.

The use of new applications of principles has been shown to be sorely needed in science education. Review literature indicating bibliographical sources of recent scientific developments (which are, of course, the new applications of principles) should be an integral part of the library of every teacher of science.

LIMITATIONS

The large number of scientific publications together with the time considerations necessarily limits the area covered by this investigation. The survey is limited to the problem as stated. It is conceded that a great number of developments have not been released to the general public for security purposes and it is not the intention here

[1] Persing, Ellis C., op. cit.

[2] Powers, Philip N., and Stickler, W. Hugh, op. cit.

to attempt to compile a complete list of developments.

The preparation of the list of developments is limited to the use of five periodicals selected according to criteria established for this investigation. Only those developments will be selected that appear to the writer to conform to the criteria established for the selection of developments.

No attempt is made to relate the developments to the underlying principles or to alter the order ot their listing as found in the various periodicals reviewed.

CHAPTER II

SURVEY OF RELATED INVESTIGATIONS

RESTATEMENT OF PROBLEM

The problem of this paper is to survey the popular scientific periodicals for the period of World War II and to list the developments that are concerned with principles of physical science with bibliographical sources. (The principles of chemistry are excluded.)

PREVIOUS SURVEYS OF SCIENTIFIC PROGRESS

There have been many so-called surveys of scientific progress and development. They, being in the most part general and short, do not give complete bibliographies if the names of the individuals involved in the developments are at all mentioned.

The important advances in science for the year are reviewed yearly by Davis[1] and the Science Service staff. The list is usually published in the next to the last issue of Science News Letter and also in Science. This review, however, merely "presents the highlights of the year's scientific progress".[2]

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[1] Davis, Watson, "Science Goes to War in 1942". Science News Letter, XLII (Dec. 19, 1942) 387-389, 398-399.

[2] Ibid., 387.

A discussion of the general scientific advancements of the month is published monthly by Kaempffert[1] in Science Digest. It is a condensed version of what has been previously presented in the New York Times.

New developments in the field of atomic energy were listed and discussed by Lawrence[2] as early as 1941. Some of the subjects mentioned were: neutrons, atomic structure, transmutation of elements, artificial radioactivity, radioactive tracer atoms, radio-autography, use in therapy, atomic energy, uranium fission, and the cyclotron.

During the period 1942 to 1945, there have been very few surveys of scientific progress. This was a natural result of war and censorship. Fernberger[3] mentions that scientific publications are affected to a greater extent during war than any other type of publication.

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[1]Kaempffert, Waldemar, "Science in the News", monthly in the Science Digest, 1941 to 1945.

[2]Lawrence, E. O., "The New Frontiers in the Atom", Science, XCIV (Sept. 5, 1941) 221-225.

[3]Fernberger, S. W., "Scientific Publication as Affected by War and Politics". Science, CIV (Aug. 23, 1946) 175-177.

Comprehensive reviews of science progress were offered by O'Connor[1] and also by Kine[2] in 1946. The year was also reviewed by Davis[4].

The most complete survey of scientific developments found was one by Lark-Horovitz and Carmichael[3] compiled for the Centennial Celebration of the American Association for the Advancement of Science. It includes developments for the period 1848 to 1948 in the following sciences:

1. Astronomy
2. Biological Sciences
3. Chemistry
4. Earth Sciences (including Meteorology)
5. Mathematics
6. Medicine
7. Physics
8. Physiology

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[1] O'Connor, A., "Scientific Progress". Catholic World, CLXII (Jan., 1946) 357.

[2] Kine, E. H., "Progress in Science". American Mercury, LXIII (Nov., 1946) 610-617.

[3] Lark-Horovitz, K. and Carmichael, Eleanor, A Chronology of Scientific Development, 1848-1948. Washington: The American Association for the Advancement of Science, 1948.

[4] Davis, Watson, "Science Progress During the War." School Science and Mathematics, XLVI (February, 1946), 193.

9. Psychology

10. Engineering-Technology

The developments are listed in groups of years, usually five, alphabetically by the name of the original investigator, when known, or by the institution concerned.

The final period surveyed is the period 1940 to 1948. Of the complete list of sciences surveyed, the following are the concern of this present investigation:

1. Astronomy

2. Earth Sciences (including Meteorology)

3. Physics

4. Engineering-Technology

In the above fields there were reported a total of 115 developments: 14 in astronomy; 2 in earth sciences; 93 in physics; and 6 in engineering-technology.

Bibliographical sources for the developments were not given in the abovementioned list of developments.

SURVEY OF IMPORTANT RESEARCH STUDIES PERTAINING TO THE DETERMINATION OF PRINCIPLES AS OBJECTIVES OF SCIENCE TEACHING

The main objective of science teaching in general education according to Conant[1] is to give a better understanding of science to those of the graduates who are

[1] Conant, James B., Loc cit.

to be lawyers, writers, teachers, politicians, public servants, and businessmen. His definition of science is "... science emerges from the progressive activities of man to the extent that new concepts arise from experiments and observation, and the concepts in turn lead to further experiments and observations."[1]

An evaluation of the objectives of science teaching was made in 1932 by Beauchamp[2]. He analyzed many courses in general science, biology, physics, and chemistry but found no conclusive method for determining and evaluating the objectives of science teaching.

The Thirty-First Yearbook Committee[3] advocated that the basic principles be the objectives of science teaching:

> ... the curriculum in science for a program of general education (should) be organized about large objectives, that understanding and enlargement of these objectives shall constitute the contribution of science teaching to the ultimate aim of education, and that the course of study be so organized that each succeeding grade level shall present an increasingly enlarged and increasingly mature development of these objectives.[4]

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[1] Ibid., 24.

[2] Beauchamp, Wilbur L., Instruction in Science, United States Office of Education, Bulletin, 1932, No. 17. National Survey of Secondary Education, Monograph No. 22. Washington: Government Printing Office, 1933.

[3] A Program for Teaching Science, Thirty-first Yearbook of the National Society for the Study of Education, Part I. Bloomington: Public School Publishing Company, 1932.

[4] Ibid., 44.

The Yearbook Committee also stated in regard to the form the large objectives shall take, "The objectives may be stated as the principles and generalizations that are functional for the individual, in that they enable him to interpret the experiences of living."[1] They go on to state that, "A functional understanding of a principle has been attained if the learner has acquired ability to associate with the principle the ideas from his immediate and from his subsequent experiences that are related to it and if he is able to apply the principles in practical situations."[2]

There have been many centers of research at which attempts have been made to clarify the concept of a scientific principle and to determine those principles which may be used as objectives of science teaching. Martin[3] states that there are three independent universities where much of this work has been done, namely:

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[1]Ibid., 43.

[2]Ibid., 43.

[3]Martin, W. Edgar, "A Chronological Survey of Research Studies on Principles as Objectives of Instruction in Science", Science Education, XXIX (February 1945), 45.

1. The University of Chicago, where the research was under the direction of Elliot R. Downing.

2. Columbia University, where the research was under the direction of S. Ralph Powers and Gerald S. Craig, and

3. The University of Michigan, where the research was under the direction of Francis D. Curtis.

As early as 1925, Downing[1] published a text in which was formulated the following three steps for the solving of a scientific problem. As will be noted, these steps involve the use of principles. They are as follows:

1. Accumulate all the facts concerning the problem.

2. Reduce the facts to generalizations to discover their relation to one another and the proper sequence.

3. Attempt discovery of the approximate causes that underlie such laws or principles.

Recognition of the importance of principles as such was gradually being absorbed by the educators. In 1927 the Department of Superintendence of the National Education Association in their Fifth Yearbook[2] stated that

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[1]Downing, Elliot R., Teaching Science In The Schools, Chicago: The University of Chicago Press, 1925, 53.

[2]Department of Superintendence of the National Education Association, Fifth Yearbook, "The Junior High School Curriculum", Washington: Government Printing Office, 1927, 150.

knowledge of science should be in the form of principles in order to be of the greatest service. Courses in science should be designed to enable the pupils to attain a functional knowledge of the socially useful principles. The application of the principles to the life situation should be given a prominent place in the course set-up.

Craig[1] stated, while planning a course of study in science for the elementary grades, that the pupils in elementary school should not be specifically trained for occupations (in this case scientists) but merely be given a general education to help them become more intelligent citizens. To accomplish this end, he states that the course of study should be such as to develop certain objectives that are in agreement with the principles of science that are necessary for the understanding of the natural phenomena which challenge the imagination of children. It was not stated, however, which principles there were that fulfilled this obligation.

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[1]Craig, Gerald S., "Certain Techniques Used In Developing A Course Of Study In Science For The Horace Mann Elementary School", Teachers College Contribution to Education, No. 276. New York: Teachers College, Columbia University, 1927, 12-13.

Notwithstanding that it was generally agreed by educators that science should be taught by means of developing an understanding of the principles of science, there have been few textbooks published for the elementary schools which devote any large amount of their space to the elucidation of principles or to the use of principles in problematic situations.

In 1923, Heinemann[1] determined in a study of science textbooks that the position of principles was one of minor importance. He analyzed twenty textbooks of general science and found only ninety-three principles. These principles occupied only a little more than twelve percent of all the reading space. Heinemann recognized that it is difficult for students in the lower grades to absorb an understanding of a great number of principles and therefore recommended placing the teaching emphasis on a small number of principles with numerous applications rather than on a large number of principles for which there are few applications. He defines a principle of science as a type of "... statement of relationship

[1]Heinemann, Ailsie ., "A Study of General Science Textbooks." General Science Quarterly, XIII (November, 1928), 11-25.

frequently causal in nature between two facts."[1] The conclusions of the investigator were that principles were not considered by the authors when the books were being written and that the several authors were not in agreement as to which principles of science are of the greatest importance at the general-science level in the schools.

A similar study in the field of biology was undertaken by Hackett[2]. He found the amount of space devoted to interpretation, discussion, and application of biological principles ranged from 48 to 23 per-cent of the total word-space of the books. He found that in each case the larger portion of the book dealt with descriptions and facts. Actually, if the facts or descriptions served to better the understanding of a principle, the word-space devoted to such facts or descriptions was counted as a part of the material belonging to a discussion of principles.

Studies similarily conducted in the fields of

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[1] Ibid., 11.

[2] Hackett, H. L., "An Analysis of High School Textbooks in Biology in Terms of Principles", unpublished Master's Thesis, Chicago: University of Chicago School of Education, 1925.

high-school physics and chemistry by Koppenaal[1] and Lucas[2], respectively, showed in both cases that the average space devoted to principles and problems involving their application was slightly less than 30 per-cent of the total word-space of the book.

Contrasting with this average figure for science texts of the secondary school, Menzies[3] found in an analysis of a dozen college biology textbooks that the minimum amount of space devoted to principles and their application was 87 per-cent and the maximum 97.6 per-cent.

Wilbur[4] analyzed fourteen textbooks in general science for the ninth grade in 1931. He found a total of 170 principles but only eighteen of the 170 were given in more than one-half of the texts analyzed.

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[1]Koppenaal, Peter, "An Analysis of High School Physics Textbooks in Terms of Principles." Unpublished Master's thesis, University of Chicago, 1932.

[2]Lucas, Loren T., "Analysis of Chemistry Texts in Terms of Principles". Unpublished Master's thesis, University of Chicago, 1932.

[3]Menzies, Jessie A., "An Analysis of Ten General Biologies of College Level in Terms of Generalizations and Their Application to Life Situations." Unpublished Master's thesis, University of Chicago, 1927.

[4]Wilbur, Oliver B., "A Study of the Principles of Science Contained in General Science Textbooks published since the beginning of the year 1924." Unpublished Master's thesis, University of Michigan, 1931.

Several studies were made at the University of Chicago to determine what principles of science are most often needed for the solution of life problems encountered by the average individual and also the order of their importance. The results of these studies were reported by Downing[1], who compiled a list of ninety-six necessary principles in biology, chemistry, and physics in the order of their importance.

At the University of Michigan, under the direction of Francis D. Curtis, various studies were made to determine the important principles of science suitable to serve as objectives of instruction in the elementary grades. The results of these completed studies were used by Robertson[2] in 1934 as sources for the compilation of a comprehensive list of major and minor principles of science. The final list contained 113 principles.

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[1]Downing, Elliot R., op. cit., 39-48.

[2]Robertson, Martin L., "The Selection of Science Principles Suitable as Goals of Instruction in the Elementary School." Science Education, XIX (February, 1935), 1-4; XIX (April, 1935), 65-70.

In 1935 at Teachers College of Columbia University, Pruitt[1] made a study to determine the concepts and generalizations in the field of chemistry which are of most value to man in the interpreting of the environment. He analyzed, during the course of the investigation, three college-entrance examinations; one year's issues of the Atlantic Monthly, The Forum, and Harper's Magazine; five books of sociology; one year's issues of eight newspapers; twelve issues each of Popular Science Monthly, Scientific American, and Science News Letter; and also sixty-five textbooks in various scientific fields. By using the same criteria for a principle as were used previously by Robertson[2], a list of 135 chemistry concepts and generalizations was prepared with the principles arranged in the approximate order of their importance.

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[1]Pruitt, Clarence Martin, "An Analysis, Evaluation, and Synthesis of Subject-Matter Concepts and Generalizations in Chemistry." Doctor's dissertation, Teachers College, Columbia University, 1935. Distributed through Science Education. See Third Digest of Investigations in the Teaching of Science by Francis D. Curtis. Philadelphia: P. Blakiston's Son and Company, Inc., 1939, 153-163.

[2]Robertson, Martin L., op. cit., 65-70.

Wise[1], in 1941, made a study to determine the principles of physical science which are of most value to general education. This involved the development of a comprehensive list of principles of physical science. This was accomplished by first compiling a complete list of principles of chemistry, geology, and physics (including astronomy and meteorology) from the lists of principles previously developed by Arnold, Hartman and Stephens, Pruitt, and Robertson. The composite list was then analyzed by a jury of three qualified persons who eliminated duplications from the list and checked the remaining principles for their adherence to the following criteria:

To be a principle, a statement

1. Must be a comprehensive generalization describing some fundamental process, constant mode of behavior, or property relating to natural phenomena.
2. Must be true without exception within limitations specifically stated.
3. Must be capable of illustration.
4. Must not be a definition.[2]

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[1] Wise, Harold E., op. cit., 371-379.

[2] Ibid., 371.

Principles which did not satisy the criteria, in the opinion of the jury, were eliminated or in some cases reworded by the jury to meet the criteria better.

The accepted tentative list contained 252 principles consisting of 165 in physics, 68 in chemistry and 19 in geology.

The list of principles was then evaluated by three subject-matter specialists for accuracy of statement.

Eleven textbooks were analyzed for applications to related principles. During this analysis twenty additional principles were formulated and added to the tentative list of 252 principles as a result of the finding of applications for which there was no stated principle. These additional principles were subjected to the same criteria and analysis as that employed in the preparation of the original list, to which they were added.

The study was finally concluded with a list of 264 principles of physical science arranged in descending order of their relative importance for general education in the secondary, intermediate, and primary grades. The relative importance of these principles was determined by Wise[1] by a synthesis of the results of 12 curricular studies in the field of science education.

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[1] Ibid., 67-76.

A study to determine the principles of biological science important to general education was made by Martin[1] in 1945. By employing a technique similar to that of Wise, a defensible list of 300 principles was developed. In the same year Martin[2] also reported a chronological survey of research studies of principles as objectives of instruction in science.

Fleish[3] reported in 1945 the formulation of a list of 60 principles of general science. This was based on a survey of pupils' interest in science in grades VII through XII in four communities in Massachusetts.

Jones[4], 1946, investigated textbooks of general science for principles. 146 principles were found but a lack of organization of textual material was evident.

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[1]Martin, W. Edgar, "A Determination of the Principles of the Biological Sciences of Importance for General Education", Science Education, XXIX (March, 1945), 100-105; XXIX (April-May, 1945), 152-163.

[2]Martin, W. Edgar, "A Chronological Survey ...", op cit., 45-52.

[3]Fleish, Sylvia, "The Formulation of the Science Principles that should become the Objectives of General Science Teaching in the Junior High School." Unpublished Master's thesis, Boston University School of Education, 1945.

[4]Jones, Ruth V., "A Study of the Principles of Science found in Ninth Grade Textbooks of General Science." Unpublished Master's thesis, University of Michigan, 1946.

A study to determine the principles of entomology of value to general education was undertaken by Bergman[1]. He analyzed general and popular entomological textbooks, reference books, and a large number of research bulletins, journals, professional biological periodicals, and miscellaneous publications. A list of 52 principles was formulated.

Keeslar[2] investigated the educational value of 24 science films. He found that the films made no definite attempt to teach scientific principles, scientific method, and scientific attitudes even though the films were fitted to teach them.

The committee on science of the National Society for the Study of Education in its Forty-Sixth Yearbook[3] stated eight types of objectives for science instruction after reviewing numerous investigations of the field. One of the eight types of objectives proposed was a functional understanding of physical science principles.[4]

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[1]Bergman, George J., "A Determination of the Principles of Entomology of Significance in General Education," Science Education, XXI (February, 1947), 23-32; XXXI (April, 1947), 144-157.

[2]Keeslar, Creon, "Contributions of Instructional Films to the Teaching of High School Science," Science Education, XXX (March, 1946), 82-88; XXX (April, 1946), 132-136.

[3]Op. cit.

[4]Ibid., 25.

Leonelli[1] analyzed 8 textbooks of 8th grade science for principles. He found only 16 physical science and 4 biological science principles contained in majority of the tests. There was a lack of agreement among the authors as to how many and which principles should be used. His investigation revealed a total of 186 principles of physical and biological science.

Lynch[2] also evaluated 8th grade science textbooks for the development of scientific principles in the areas magnetism and electricity.

Silverman[3] analyzed 4 textbooks of high-school chemistry for subject-matter topics desirable to develop understandings of principles of physical science. He concluded that there was much material in the books reviewed that made no contribution to the understanding of a principle.

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[1]Leonelli, Renato E., "Principles of Physical and Biological Science found in Eight Textbooks of General Science for Grade Eight." Unpublished Master's thesis, Boston University School of Education, 1947.

[2]Lynch, I. M., "The Relative Values for Eighth Grade General Science of Topics and Experiments in the Area Magnetism and Electricity for the Development of Related Scientific Principles." Unpublished Master's thesis, Boston University School of Education, 1947.

[3]Silverman, Joseph, "Topics suitable for Developing Understandings of Principles of Physical Science in a Course in Senior High School Chemistry." Unpublished Master's thesis, Boston University School of Education, 1947.

Annacone[1] prepared a composite topical outline of the subject-matter topics found in five high-school textbooks of physics as a source of informational material with which to develop understandings of principles of physical science, and assigned to principles of physical science those topics of which a study might reasonably be expected to contribute to the development of an understanding of the principles. He found an apparent uniformity in relation to the major subject-matter topics to be studied at the secondary level. It was suggested that textbooks can be used to help develop understandings of principles of physical science, provided that the content is properly treated.

Brudzynski[2] selected from four textbooks of physics for the senior high-school statements which can be justifiable in their assignment to the principles of physical science compiled by Wise[3]. He found that the more recent books (1946) contained a larger number of principles than the older ones (1943).

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[1]Annacone, Angelo L., "Topics Suitable for Developing Understandings of Principles of Physical Science in a Course in Physics for the Senior High School." Unpublished Master's thesis, Boston University School of Education, 1948.

[2]Brudzynski, A. J., "Principles of Physical Science found in Physics Textbooks for the Senior High School." Unpublished Master's thesis, Boston University School of Education, 1948.

[3]Op. cit.

SUMMARY OF RESEARCH STUDIES

The National Society for the Study of Education recommended in the Thirty-First Yearbook that courses in science can best contribute to the objectives of science education when organized around principles of science. Beauchamp analyzed many courses in science but found no conclusive method for determining and evaluating the objectives of science teaching. Subsequent independent studies were undertaken at the University of Chicago, under Downing; Columbia University, under Powers and Craig; New York University, under Robertson; University of Michigan, under Curtis; and also at Boston University, under Miles and Read.

Studies of science textbooks by Heinemann, Hackett, Koppenaal, and Lucas showed that the average space devoted to principles and problems involving their application was only a small portion of the total word-space of the textbooks.

Downing, Robertson, Wise, and Martin formulated lists of principles of the physical sciences and the biological sciences most often needed for the solution of life problems encountered by the average individual.

Fleish and Jones found that textbooks of general science do not agree as to the number, selection and

relative importance of principles. Keesler found that science films made no definite attempt to teach scientific principles even though the films were fitted to teach them. Studies by Leonelli, Lynch, Silverman, Annacone, and Brudzynski, indicate a gradual increase in the use of principles by the writers of science textbooks as objectives of science instruction.

RESTATEMENT OF THE PROBLEM

The problem of this paper is to survey the popular scientific periodicals for the period of World War II and to list the scientific developments which are concerned with the principles of physical science as formulated by Wise[1] (excluding those dealing specifically with chemistry).

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[1] Loc. cit.

CHAPTER III

PREPARATION OF CHRONOLOGICAL LIST OF DEVELOPMENTS

TECHNIQUES EMPLOYED

Use of principles of physical science. The principles of physical science formulated by Wise[1] will be thoroughly studied by the investigator to form a basis for the selection of developments. Wise used the following criteria to determine the principles in physical science:

A. To be a principle, a statement must be a comprehensive generalization describing some fundamental process, constant mode of behavior, or property relating to natural phenomena.

B. It must be true without exception within limitation specifically stated.

C. It must be capable of illustration.

D. It must not be a definition.[2]

A total of 252 principle was found; 165 were in physics, including astronomy and meteorology, 19 in geology, and 68 in chemistry. The latter principles in chemistry will not be used in this paper.

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[1] Wise, Harold E., loc. cit.

[2] Ibid., 371.

Selection of periodicals for analysis. The following criteria were adopted by the writer and approved by the science educators attending a Seminar in Science Education at the Boston University School of Education, 1948, as a basis for the selection of periodicals to be analyzed for developments in physical science.

The periodical must ...

1. have been published by a scientific organization or publisher and have a circulation over 10,000.
2. Be non-technical, i.e., published for the layman and not the specialist in the field.
3. Be published either weekly or monthly.
4. Be available to the writer at the time of the writing.
5. Be published during the period starting January 1, 1941 and ending December 31, 1945.
6. Be representative of the periodicals used in high school science departments.

Periodicals selected. Five periodicals were found to satisfy the criteria:

1. Science News Letter, published weekly by Science Service, Washington, D. C.
2. Science, published weekly by the American Association for the Advancement of Science, Washington, D. C.

3. Scientific Monthly, Published monthly by the American Association for the Advancement of Science, Washington, D. C.

4. Science Digest, published monthly by the Science Digest, Incorporated, Chicago, Illinois.

5. Popular Science, published monthly by the Science Publishing Company, New York.

Selection of developments in physical science. The following criteria were established by the writer and approved by the science educators attending a Seminar in Science Education at the Boston University School of Education, 1948, as a basis for the selection of developments in physical science from the periodicals.

The development must ...

1. Deal with one or more of the principles listed by Wise[1] excluding those in the field of chemistry.

2. Mention a new process, invention, technique, or other type of new development of the basic principle or principles.

3. Be understandable to the non-scientific layman on the secondary level. The writer's opinion

[1] Ibid., 371-379.

based on his experience and training will be the judge of this criterium.

4. Mention the name of the investigator.
5. Mention the place and approximate time of the investigation.

Technique used to survey the literature. Wise's list of principles of physical science will be studied by the investigator until they are thoroughly understood. The periodicals chosen will then be surveyed one after another page by page. The selected developments will be written in non-technical narrative style together with complete bibliographies. The total issues for the year of all five periodicals will be surveyed before going to the next year. This procedure will be followed for the complete five years. The developments will be reported in this investigation in the order they are found in the periodicals.

THE RESEARCH

Treatment of data. The developments located in the selected periodicals according to the criteria established will be listed in TABLE I together with their complete bibliographical sources.

The number of developments in physical science found in each periodical for each year surveyed will be found

in TABLE II.

The numbers of the developments listed in TABLE I that are mentioned in two or more sources will be found in TABLE III.

Assumptions made. It is assumed that the periodicals chosen for this survey represent a comprehensive coverage of the scientific developments of World War II. It is further assumed that the judgment of the investigator in choosing the developments according to the criteria is reliable, i.e., the developments chosen will not be above the comprehensive powers of the average secondary school science student.

STATEMENT OF THE PROBLEM

The problem of this paper is to survey the popular scientific periodicals for the period of World War II and to list the scientific developments which are concerned with the principles of physical science as formulated by Wise[1] (excluding those dealing specifically with chemistry).

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[1] Loc. cit.

TABLE I

SUMMARY OF DEVELOPMENTS IN PHYSICAL SCIENCE PUBLISHED IN FIVE PERIODICALS DURING THE PERIOD JANUARY 1, 1941 TO DECEMBER 31, 1945

	Development	Source
1.	A method of spinning a steel ball, 3/32 inch in diameter, at 110,000 revolutions per second by magnetically suspending it in vacuum. *	E. L. MacHattie, University of Virginia. Reported in Science News Letter, 39 (Jan. 4, 1941) 3, 11-12.
2.	Blind-flying bats use supersonic echoes to pilot themselves through maze of wires in room. When their ears and mouths were covered, the bats were helpless.	R. Galambas and D. R. Griffin, Harvard Biological Laboratories. Reported in Science News Letter, 39 (Jan. 4, 1941) 5-6.
3.	A photographic exposure meter which measures the direct light, at the source, rather than that reflected from the subject.	D. Norwood, Society of Motion Picture Engineers. Reported in Science News Letter, 39 (Jan. 11, 1941) 25.
4.	A stop-light for bicycles which operates when the direction of the pedals is reversed.	R. K. Johnston, Hamilton, Ohio. Reported in Science News Letter, 39 (Jan. 11, 1941) 30.
5.	An instrument for making movies of stars and planets for educational purposes.	Dr. R. R. McGrath, University of Michigan. Reported in Science News Letter, 39 (Jan. 25, 1941) 56.

*Table I is read thus: the development "A method of spinning ... in vacuum" was developed by E. L. MacHattie at the University of Virginia and reported in Science News Letter, 39 (Jan. 4, 1941) 3, 11-12.

TABLE I, (CONTINUED)

	Development	Source
6.	Fuse for time shell uses weights instead of springs to drive the timing mechanism. The centrifugal force of the spinning projectile actuates the timer.	F. W. Bold, Chelsea, Massachusetts. Reported in Science News Letter, 39 (Feb. 1, 1941) 76.
7.	Multifocal lenses with no sharp line of demarcation between the sections for near and far vision. The one eases gradually into the other.	Beach Lens Company, Buffalo, New York. Reported in Science News Letter, 39 (Feb. 8, 1941) 89.
8.	"Kovar", an alloy of iron, nickel, cobalt and manganese, has a coefficient of expansion the same as glass. Used in manufacture of radio, X-ray, and television tubes to prevent strain between metal and glass surfaces due to expansion and contraction by temperature variations.	H. Scott, Westinghouse Research Department. Reported in Science News Letter, 39 (March 1, 1941) 135.
9.	Production of high purity Magnesium by distillation of scrap castings.	C.E.Nelson, Dow Chemical Company. Reported in Science News Letter, 39 (March 1, 1941) 136.
10.	Radio waves (600 megacycles or 20 inches long) used to detect airplanes at night. The waves are sent out in straight paths and are reflected by metallic objects.	J. Lyman, Huntington, New York. Assigned to Sperry Gyroscope Company, Brooklyn, New York. Reported in Science News Letter, 39 (March 9, 1941) 147.

TABLE I, (CONTINUED)

	Development	Source
11.	Aerial photographs developed and printed aloft in seven minutes. The film is exposed, developed and fixed while still in its original holder. The prints are made from the wet negative.	H. F. Stiffler, United States Army Air Corps, Wright Field, Dayton, Ohio. Reported in Science News Letter, 39 (March 8, 1941) 148.
12.	Radioactive Carbon isotope C-14 prepared in appreciable quantities with cyclotron.	Drs. S. Ruben and M. D. Kamen, University of California. Reported in Physical Review and Science News Letter, 39 (March 15, 1941) 165.
13.	Uranium U-235 split into equal parts with a release of large amount of energy in the cyclotron.	Drs. E. Segre and G. Seaborg, University of California. Reported in Science News Letter, 39 (March 15, 1941) 164.
14.	The presence of invisible viruses revealed through color changes of very thin films of transparent material.	Dr. I. Langmuir, General Electric Research Laboratory. Reported in Science News Letter, 39 (March 15, 1941) 164.
15.	Castings of snowflakes, preserving permanently in synthetic fossil form all details of their delicate microscopic structure, made in chemical plastic.	V. J. Schaefer, General Electric Research Laboratory. Reported in Science and in Science News Letter, 39 (March 15, 1941) 171-172.

TABLE I, (CONTINUED)

	Development	Source
16.	Detection of airplanes at night through the use of the infra-red rays from the engine's exhaust.	I. Wolff, Merchantville, New Jersey. Assigned to Radio Corporation of America. Reported in Science News Letter, 39 (March 29, 1941) 206.
17.	Magnetization of small iron objects by placing them at right angles to the earth's magnetic field and subjecting them to ultra-violet rays from a sun-lamp concentrated by quartz lenses.	Dr. F. Ehrenhaft and L. Banet, New York. Reported in Nature and Science News Letter, 39 (April 12, 1941) 232.
18.	Detection of presence and counting of meteors during daylight hours (when the meteors are invisible) by use of high frequency radio waves.	Dr. J.A.Pierce, Harvard University. Reported in Physical Review and Science News Letter, 39 (May 17, 1941) 316.
19.	Night-glow of sky proven to be due to magnetic activity of earth and its atmosphere rather than to just star and moon light.	D. H. Barber, University of California. Reported in Science News Letter, 39 (Aug. 2, 1941) 78.
20.	Pictures may be taken in darkness by use of infra-red flash bulbs and infra-red film.	Wabash Photolamp Corporation, Brooklyn, New York. Reported in Science News Letter, 39 (Aug. 23, 1941) 115-116.

TABLE I, (CONTINUED)

Development	Source
21. Opening the field of study on size, shape, and distribution of colloidal particles, structure of plastics, and other heretofor invisible objects through the use of the electron microscope.	Smith, T. A., Engine Products Division of Radio Corporation of America. "The Electron Microscope", Scientific Monthly, 52 (April 1941) 337-341.
22. Forcasting of weather changes by "air-mass analysis" system of weather study. More dependable than "barometric system" since it deals with the whole atmosphere of a region rather than a limited number of phenomena.	Dr. A.K.Botts, N.J. State Teachers College, Trenton, New Jersey. "The Character of Weather", Scientific Monthly, 52 (June, 1941) 534-538.
23. High-pitched sound waves directed into chimneys, clears them of smoke, dust and smelter fumes. "The solid particles in the atmosphere form flakes, like soot, and fall to the bottom."	H. W. St. Clair, United States Bureau of Mines. Reported in "Science News", Science, 93 (Jan. 17, 1941) 10-11.
24. Detection of cosmic rays in "Wilson cloud chamber". It is a cyclinder containing damp air in which the pressure is alternately raised and lowered. As the expansion takes place, a line of fog will form on the trail of atomic fragments left in the wake of a cosmic ray.	Dr. T. H. Johnson, Franklin Institute. Reported in "Science News", Science, 93 (Feb. 7, 1941) 43-44.

TABLE I, (CONTINUED)

	Development	Source
25.	Determination of the age of deposits of ocean mud by measuring the amount of radium in the mud.	Dr. W. D. Uvry, Carnegie Institute of Washington. Reported in "Science News", Science, 93 (Feb. 7, 41) 44.
26.	"The extraction of antigens by sound waves."	Drs. L.A.Chambers and E.W.Flosdorf, University of Pennsylvania. Reported in "Science News", Science, 93 (Feb. 21, 41) 10.
27.	"Detection of airplanes at night or through fog." See Development No. 10.	J. Lyman, Sperry Gyroscope Company. Reported in "Science News", Science, 93 (Feb. 28, 41) 6. Also in Science News Letter, 39 (March 9, 1941) 147.
28.	"A method of making snowflake replicas." See Development No. 15.	V. J. Shaefer, General Electric Research Laboratory. Reported in Science, 93 (March 7, 1941) 239-240. Also in Science News Letter, 39 (March 15, 1941) 172.
29.	"Radium-like Carbon made from Nitrogen". See Development No. 12.	Drs. S. Ruben and M.D. Kamen, University of California. Reported in Physical Review; "Science News", Science, 93 (Mar. 7, 1941) 10; and Science News Letter, 39 (March 15, 1941) 163.

TABLE I, (CONTINUED)

	Development	Source
30.	"Aerial photographs" taken and printed aloft. See Development No. 11.	H. F. Stiffler, United States Army Air Corps, Wright Field, Dayton, Ohio. Reported in "Science News", Science, (March 7, 1941) 12; and in Science News Letter, 39 (March 8, 1941) 148.
31.	Splitting of Uranium into equal parts. See Development No. 13.	Dr. E. Segre and G. Seaborg, University of California. Reported in "Science News", Science, 93 (March 8, 41) 14; and in Science News Letter, 39 (March 15, 1941) 164.
32.	"Iridescent colors of thin films of transparent material for the detection of disease." See Development No. 14.	Dr. I. Langmuir, General Electric Research Laboratory. Reported in Science News Letter, 39 (March 15, 1941) 164; and in "Science News", Science, 93 (March 21, 1941) 6.
33.	Determination of density of different atmospheric layers by "shooting radio waves up into the higher layers of the atmosphere and measuring the brief period required for the echo to return."	Dr. L. V. Berkner, Carnegie Institute Department of Terrestial Magnetism. Reported in "Science News", Science, 93 (March 28, 1941) 8.

TABLE I, (CONTINUED)

Development	Source
34. "A glare-eliminating screen for automobiles uses invisible submicroscopic molecules instead of crystals to line up light waves so that they all vibrate in the same direction."	E. H. Land, Polaroid Corporation, Cambridge, Massachusetts. Reported in "Science News", Science, 93 (April 18, 1941) 10,12.
35. Musical device using vacuum tubes and electrical circuits "can play tunes of any instrument desired.	R. W. Burnstead, Westfield, New Jersey. Assigned to Radio Corporation of America. Reported in "Science News", Science, 93 (May 16, 1941) 10.
36. An inexpensive process for producing aluminum from alunite.	Dr. A. Fleischer, Kalunite, Inc., Salt Lake City. "Science News", Science, 94 (July 4, 1941) 11.
37. Use of sun's rays to cook food. A parabolic reflector, following the sun by clockwork, focuses the rays on a tube of high boiling-point liquid. The liquid heats and circulates through a cooking oven.	Dr. C. G. Abbot, Smithsonian Institution, Washington. Reported in "Science News", Science, 94 (July 18, 1941) 10.
38. Night glow in sky due to magnetic activity, not starlight. See Development No. 19.	Dr. D. R. Barber, University of California. Reported in "Science News", Science, 94 (July 25, 1941) 8. Also in Science News Letter, 39 (Aug. 2, 1941) 78.

TABLE I, (CONTINUED)

	Development	Source
39.	Measurement of airplane's height above ground by use of high frequency radio signal and its reflection from the ground.	Dr. E.F.W.Alexanderson, General Electric Company. Reported in "Science News", Science 94 (July 25, 1941) 8.
40.	Measurement of airplane's distance to a reference station by use of high frequency radio signal from airplane and an automatic retransmission of signal from reference station.	H. T. Budenborn, Bell Telephone Laboratories. Reported in "Science News", Science, 94 (July 25, 1941) 10.
41.	Pictures may be taken in darkness by use of infra-red flash bulbs and infra-red film. See Development No. 20.	Wabash Photolamp Corporation, Brooklyn, New York. Reported in "Science News", Science, 94 (Aug. 8, 1941) 8. Also in Science News Letter, 39 (Aug. 23, 1941) 115-116.
42.	Rats can hear frequencies up to forty kilocycles.	J. Gould and C. Morgan, Harvard University. "Hearing in the Rat at High Frequencies", Science, 94 (Aug. 15, 1941) 168.
43.	Liquid air may be made by allowing compressed air to do work as it expands.	P. Kapitza, Institute of Physical Problems of Academy of Sciences, Moscow, U.S.S.R. Reported in Nature. Also in "Science News", Science, 94 (Aug. 15, 1941) 8.

TABLE I, (CONTINUED)

	Development	Source
44.	Generator that produces sound waves lethal to bacteria and other micro-organisms.	Dr. A.P.Krueger, University of California at Berkeley. Reported in "Science News", Science, 94 (Sept. 5, 1941) 12.
45.	Removal of reflections from the surface of lenses by use of hydrofluoric acid fumes to etch away a small amount of surface and leave a thin transparent film of calcium fluoride on the surface.	Dr. F.H.Nicoll, Radio Corporation of America Laboratories. Reported in "Science News", Science, 94 (Oct. 31, 1941) 8.
46.	High power mercury arc lamps to speed up production of blueprints. The lamps emit a very high intensity of light in the near ultra-violet region of which the blueprint paper is very sensitive thus shortening the required exposure.	W. T. Anderson, Jr. Hanovia Chemical and Manufacturing Company, Newark, New Jersey. Described at meeting of Optical Society of America. Reported in "Science News", Science, 94 (Oct. 31, 1941) 11.
47.	Reduction of static electricity charge on autombiles from 7000 volts to 1,200 volts by injecting a conducting powder into the inner tube through the valve stem. The powder forms a continuous conducting layer which reduces the charges which otherwise would be induced on the car.	S,M,Cadwell, et al, United States Rubber Company. Described to American Chemical Society. Reported in "Science News", Science, 94 (Nov. 7, 1941) 12.

TABLE I, (CONTINUED)

	Development	Source
48.	High-speed photography with ordinary cameras through use of Kodatron Flash tube. Flash accomplished by discharge of condenser through tube.	Developed by Dr. H. E. Edgarton, Massachusetts Institute of Technology. Reported in Popular Science, 138 (Feb. 1941) 208-210.
49.	Camera to reduce the negative size of X-Ray photographs to 4" x 5" instead of customary 14" x 17".	General Electric X-Ray Corporation. Reported in Popular Science, 138 (March 1941) 87.
50.	Bats use supersonic cries during flight to "see" in dark. See Development No. 2	R. Galambas and D.R. Griffin, Harvard Biological Laboratory. "How Bats 'See' in the Dark" by E. Teale, Popular Science, 138 (March, 1941) 102-104.
51.	Microscope for drill presses that locates a desired drill point to within .00018 inch.	S. Griffin, Glendale, California. Reported in Popular Science, 139 (July, 1941) 55.
52.	Commercial transmission of full-color television.	Dr. P.C. Goldmark, Columbia Broadcasting System, New York. Reported by Popular Science, 139 (July, 1941) 65.
53.	Measurement of thickness of sheets of magnetic material by the use of a magnetic gauge accurate to .001 inch even when only one side is accessible.	General Electric Company Reported in Popular Science, 139 (July, 1941) 81.

TABLE I, (CONTINUED)

Development	Source
54. Use of micro-waves and infra-red rays to detect airplanes at night. See Developments No. 10, 16, 27, and 39.	"How Warplanes Fight at Night", Popular Science, 139 (Oct. 1941) 82-88, 220-222.
55. Balloon-carried weather station, "Radiosonde", automatically transmits weather information.	U. S. Weather Bureau. "New Planes for Ocean Travel" by D. M. Stearns, Popular Science, 139 (Nov. 1941) 81-85.
56. Termite detector uses radio to amplify the sounds of the insects chewing the fibers inside wood objects.	W. Burgess and W. Burgess, Jr., Benton Harbor, Michigan. Reported in Popular Science, 139 (Nov. 1941) 85.
57. "Flames" on Sun visible with spectro-helioscope. Allows transmission of wavelength of hydrogen light but excludes all others.	J. W. Evans, Chabot Observatory, Oakland, California. Reported in Science Digest, 9 (Jan. 1941) 11-12.
58. Blind-flying bats use supersonic echoes to pilot themselves through the dark. See Developments No. 2, 50.	K. Galambos and D. R. Griffin, Harvard Biological Laboratories. "The Advancement of Science", Science Digest, 9 (March, 1941) 42-48.
59. Spinning a steel ball 110,000 times a second by magnetically suspending it in a vacuum. See Development No. 1.	L. E. MacHattie, University of Virginia. "The Advancement of Science", Science Digest, 9 (March, 1941) 42-48.

TABLE I, (CONTINUED)

Development	Source
60. Detection of airplanes at night by use of infra-red rays from exhaust of plane. See Development No. 16.	I. Wolff, Merchantville, New Jersey. Reported in Science Digest, 9 (June, 1941) 96.
61. A "voice-dialing" telephone system which automatically connects the called party when the proper number is spoken into the transmitter.	H. W. Dudley, Garden City, New York. Assigned to Bell Telephone Laboratories. Reported in Science Digest, 10 (July, 1941) 94.
62. Use of infra-red flash bulbs to take pictures in total darkness. See Developments No. 20,41.	Wabash Photolamp Corporation, Brooklyn, New York. Reported in Science Digest, 10 (Oct., 1941) 95.
63. Powder eliminates static interference and static shock caused by friction of rotating parts. See Development No. 47.	U. S. Rubber Company. Reported in Science Digest, 10 (Oct., 1941) 95.
64. Sound generator kills bacteria and other micro-organsims with very short waves. See Development No. 44.	Dr. A. P. Krueger, University of California. Reported in Science Digest, 10 (Nov., 1941) 93.
65. Radio frequency circuit with movable coil used to locate metal fragments for surgery.	Col. J. J. Moorhead, U. S. Army Post Graduate School, New York. Reported in Science News Letter, 41 (Jan. 31, 1942) 67.

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TABLE I, (CONTINUED)

	Development	Source
66.	Use of low power "induction field" in immediate vicinity of antenna facilitates blind landing of airplanes.	W. L. Clemmer, Monroe, Wisconsin. Reported in Science News Letter, 41 (Jan. 31, 1942) 72.
67.	Propellerless, jet-driven airplane built and tested successfully in Italy.	S. Campini. Reported in British Aviation journal, The Aeroplane, Dec., 1941. Also in Science News Letter, 41 (Feb. 7, 1942) 89.
68.	Planes can photograph enemy territory at night by dropping flares which flash only once for a very short duration. The camera shutter is synchronized with the flash by means of a photo-electric cell.	E. E. Johnson, General Electric Laboratory. Reported in Science News Letter, 41 (March 28, 1942) 201.
69.	Beam of electrons sweeping back and forth across a photographic film at speed up to 18,000 miles per second, a tenth that of light, times a lightning flash to a few billionths of a second, measures the current and voltages, and draws a picture of the oscillations.	E. J. Wade, et al, General Electric Corporation. Reported in Science News Letter, 42 (July 4, 1942) 3.
70.	Electron microscope that scanns the object permits study of grain structure of opaque objects and allows the picture to be transmitted by television.	Dr. V. K. Zworykin, et al, Radio Corporation of America Laboratory. Reported in Science News Letter, 42 (July 11, 1942) 20-21.

TABLE I, (CONTINUED)

	Development	Source
71.	Thermocouple surrounded by a damp cloth provides a method for obtaining direct readings of relative humidity.	F. Kahn, Philadelphia. Reported in Science News Letter, 42 (Aug. 29, 1942) 137.
72.	Reprocessing techniques remove surface scratches from photographic film.	Col. R. C. Barrett, United States Army Signal Corps Photographic Laboratory, Washington. Reported in Science News Letter, 42 (Dec. 5, 1942) 355-356.
73.	Device which allows rapid counting of stars on a photographic plate as faint as the fifth magnitude, regardless of the number of stars on the plate.	Dr. W. W. McCushey, Warner and Swasey Observatory, Cleveland. Reported in Science, 95 (Jan. 9, 1942) 13.
74.	Blind landing of airplanes facilitated by use of a low-power, low-frequency transmitter which sets up an "induction field". See Development No. 66.	W. C. Clemmer, Monroe, Wisconsin. "Science News", Science, 95 (Jan. 30, 1942) 6-7.
75.	Radio frequency circuit with movable coil used to locate metal fragments for surgery. See Development No. 65.	Col. J. J. Moorhead, United States Army Post Graduate School, New York. Reported in Science, 95 (Jan. 30, 1942) 8.
76.	Worn machine parts can be built up to their original dimensions by spraying the worn part with a fine mist of molten metal.	W. T. Cummings, Surface Transportation Corporation. "Science News", Science, 95 (Feb. 20, 1942) 10.

TABLE I, (CONTINUED)

	Development	Source
77.	Beam of electrons sweeping back and forth across a photographic film at speed up to 18,000 miles per second, a tenth that of light, times lightning flashes to a few billionths of a second, measures the current and voltages, and draws a picture of the oscillations. See Development No. 65.	E. J. Maude, et al, General Electric Corporation. "Science News", Science, 96 (July 3, 1942) 10.
78.	Development of the "Sterilamp", the ultraviolet rays of which are lethal to some forms of harmful bacteria.	Dr. H. C. Mentschler, Westinghouse Laboratory. "Death Rays for Bacteria" by K. M. Swezey, Popular Science, 140 (Jan., 1942) 49-51.
79.	Electronic vacuum camera can photograph crystalline structure of substances billionths of an inch thick.	Dr. R. F. Johnson, General Electric Research Laboratory. Reported in Popular Science, 140 (Jan., 1942) 52.
80.	Treatment of glass surfaces with hydrofluoric acid fumes eliminates reflections. See Development No. 45.	Dr. F. H. Nicoll, Radio Corporation of America Laboratories. Reported in Popular Science, 140 (Feb., 1942) 122.
81.	Cosmic rays leave a visible trail of condensed moisture in cloud chamber. See Development No. 24.	Dr. C. D. Anderson, California Institute of Technology. Reported in Popular Science, 141 (Sept., 1942) 44-45.

TABLE I, (CONTINUED)

Development	Source
82. By means of a special film, "Trivision", a single X-ray picture can be made to show three dimensions - length, breadth and depth.	D. F. Winnek, Mt. Vernon, New York. Reported in Popular Science, 141 (Sept., 1942) 88-90.
83. Gun projectiles can be propelled by use of the expanding force of dry-ice (carbon dioxide).	R. Monner, Denver, Colorado. Reported in Popular Science, 141 (Oct., 1942) 65.
84. Treatment of glass surfaces with hydrofluoric acid fumes eliminates reflections. See Developments No. 45, 80.	Dr. F. H. Nicoll, Radio Corporation of America Laboratories. Reported in Popular Science and "Science in the News" by W. Kaempffert, Science Digest, 11 (Jan., 1942) 73.
85. Typewriter-camera photographs the letters as they are punched on film. Duplicates or copies may then be reproduced photographically.	J. N. Bryce, Glen Ridge, New Jersey. Reported in the New York Times and also in Science Digest, 11 (Feb., 1942) 95.
86. Propellerless, jet-driven airplane built and tested successfully in Italy.	S. Campini, Italy. Reported in British aviation journal, The Aeroplane, Dec., 1941. Also in Science Digest, 11 (April, 1942) 94.
87. Radio frequency circuit with movable coil used to locate metal fragments for surgery. See Developments No. 65 and 75.	Col. J. J. Moorhead, United States Army Post Graduate School, New York. Reported by Science Service and in Science Digest, 11 (May, 1942) 93-94.

TABLE I, (CONTINUED)

	Development	Source
88.	By means of a special film, "Trivision", a single X-ray picture can be made to show three dimensions. See Development No. 82.	D. F. Winnek, Mt. Vernon, New York. Reported in Science Digest, 12 (July, 1942) 95-96.
89.	Magnetically recording sound on thin steel wire.	M. Camras, Armour Research Foundation. Reported in Science Digest, 12 (Sept, 1942) 93.
90.	TNT (trinitrotoluene) can be used as a light-sensitive coating for photographic paper.	Dr. W. C. Snelling, Trojan Powder Company. Reported in Plum Brook Ordnance Works News. Also in "Science News", Science News Letter, 43 (Jan. 2, 1943) 9.
91.	Wide-angle periscope increases the visibility of tank commander.	Lt. Col. D. J. Crawford, United States Army. Reported in Science News Letter, 43 (Feb. 13, 1943) 104.
92.	"Stitching" metal sheets together accomplished by automatic spot-welder.	Budd Company. "Electricity Sews Metal", Science News Letter, 43 (Feb. 20, 1943) 118.
93.	Rocket motors act as auxiliary power units to assist overloaded airplanes in take-off.	R. Healy, American Rocket Society. Reported in Aviation. Also in Science News Letter, 43 (Feb. 20, 1943) 118-119.

TABLE I, (CONTINUED)

	Development	Source
94.	Rubber inner walls on gasoline tanks seal up holes from bullets.	A. J. DeCamp, Moline, Colorado. Reported in Science News Letter, 43 (Feb. 20, 1943) 120.
95.	Plastic propeller-shaft bearings on ships are not corroded by salt spray.	V. E. Enz, Westinghouse Corporation. Reported in Science News Letter, 43 (Feb. 20, 1943) 120.
96.	Muzzle attachment utilizes power of blast to prevent submachine gun from "climbing".	E. G. Reising, Hartford, Conn. Reported in Science News Letter, 43 (Mar. 27, 1943) 205.
97.	Copper-covered steel wire transmits high frequencies as well as solid copper conductors.	Dr. B. R. Teare, Jr. and J. R. Webb, Carnegie Institute of Technology. Reported in Science News Letter, 43 (Mar. 27, 1943) 207.
98.	Floating automatic radio transmitters used to survey ocean currents.	Dr. L. O. Colbert, United States Coast and Geodetic Survey. "Robots to Study Ocean", Science News Letter, 43 (May 1, 1943) 275.
99.	Plastic materials may be joined together by use of radio-frequency current instead of needle and thread in a "sewing" machine.	Dr. G. H. Brown, Radio Corporation of America Laboratories. Reported in Science News Letter, 43 (June 12, 1943) 372.
100.	Flaws in rubber tires detected by means of supersonic waves.	Goodyear Research Laboratories. Reported in Science News Letter, 44 (July 3, 1943) 4.

TABLE I, (CONTINUED)

	Development	Source
101.	Magnetic field detects flaws or irregularities in wires, rods and similar elongate metals shapes as they move at forty feet per second.	D. E. Elmendorf and K. H. Keller, General Electric Company. Reported in Science News Letter, 44 (Aug. 28, 1943) 136.
102.	Plastic may be molded by heat produced by high-frequency radio waves.	V. E. Meharg, Bakelite Corporation. Reported in Science News Letter, 44 (Sept. 18, 1943) 180-181.
103.	Supersonic waves used to prepare homogeneous emulsions.	Dr. K. Sollner, University of Minnesota. Reported in Science News Letter, 44 (Sept. 18, 1943) 181.
104.	Destruction by ultraviolet light of the virus type of disease germ. See Development No. 78.	Dr. H. C. Rentschler, Westinghouse Lamp Division. "Science News", Science, 97 (April 23, 1943) 12.
105.	Floating automatic radio transmitters used to survey ocean currents. See Development No. 98.	Dr. L. C. Colbert, United States Coast and Geodetic Survey. "Science News", Science, 97 (May 7, 1943) 12.
106.	Supersonic waves used to prepare homogeneous emulsions. See Development No. 103.	Dr. K. Sollner, University of Minnesota. "Science News", Science, 98 (Sept. 17, 1943) 12.
107.	Plastic may be molded by heat produced by generated radio waves. See Development No. 102.	V. E. Meharg, Bakelite Corporation. "Science News", Science, 98 (Sept. 17, 1943) 12, 14.

TABLE I, (CONTINUED)

	Development	Source
108.	TNT (trinitrotoluene) can be used as a light-sensitive coating for photographic paper. See Development No. 90.	Dr. W. C. Snelling, Trojan Powder Company. Reported in Popular Science, 143 (Aug., 1943) 122.
109.	Rocket motors act as auxiliary power units to assist overloaded airplanes in take-off. See Development No. 93.	R. Healy, American Rocket Society. Reported in Aviation. Also in Science Digest, 13 (April, 1943) 56.
110.	Electrostatic heating uses the product being heated as the dielectric of a condenser. Heat is generated as a result of molecular agitation.	P. D. Zotto, Thermex Division of the Girdler Corporation, Louisville, Kentucky. Reported in Product Engineering. Also in Science Digest, 13 (April, 1943) 95.
111.	Use of Radar (Radio Directing and Ranging) to obtain information and movement data about astronomical bodies.	Dr. C. H. Caldwell, Electronic Industries. Reported also in Science Digest, 14 (Aug., 1943) 68.
112.	Flaws in rubber tires detected by means of supersonic waves. See Development No. 100.	Goodyear Research Laboratories. Reported by Science Service/Science News Letter. Also by Science Digest, 14 (Sept., 1943) 96.
113.	Process of dehydrating food by means of high frequency radio energy.	Federal Telephone and Radio Corporation. Reported in Electrical Communication. Also in Science Digest, 14 (Oct. 1943) 95-96.

TABLE I, (CONTINUED)

	Development	Source
114.	Robot control mechanism, the "amplidyne", receives directions from weak electrical impulses.	Dr. E. F. W. Alexanderson, General Electric Research Laboratories. Reported in Science Digest, 14 (Nov., 1943) 95-99.
115.	Treatment of glass surfaces with hydrofluoric acid fumes eliminates reflections. See Developments No. 45, 80, 84.	Radio Corporation of America. Reported in Science Digest, 14 (Dec., 1943) 99.
116.	Waste sawdust and shavings from sawmills used to make a black opaque plastic of high tensile strength and high resistance to moisture.	Dr. R. A. Hardin, University of Oklahoma. "Plastic from Sawdust", Science News Letter, 45 (Jan. 1, 1944) 2.
117.	Hidden pools of oil detected by irradiating samples of the earth above the suspected pool with ultraviolet light. If petroleum gases are present, a characteristic fluorescent glow will appear.	L. W. Blau, Houston, Texas. Assigned to Standard Oil Development Company. Reported in Science News Letter, 45 (Jan. 1, 1944) 8.
118.	X-rays used to check the strength of spot-welds without destroying the weld.	Dr. R. C. McMaster, California Institute of Technology. Reported in Science News Letter, 45 (Jan. 1, 1944) 14.
119.	Electric motor developed that has a speed of 120,000 revolutions per minute.	D. H. Ware, General Electric Company. Reported in Science News Letter, 45 (Feb. 26, 1944) 131.

TABLE I, (CONTINUED)

	Development	Source
120.	Food materials may be dehydrated by use of high-voltage, high-frequency current. See Development No. 113.	A. Vang, Newark, New Jersey. Reported in Science News Letter, 45 (April 1, 1944) 221.
121.	X-rays used to measure the thickness of white-hot steel sheets squeezed out between rollers at a speed of 20 miles per hour.	Dr. W. D. Coolidge, General Electric Corporation. Reported in Science News Letter, 45 (April 29, 1944) 275-276.
122.	Ultra-short radio waves used to sterilize vaccine, serum, etc., in plastic ampoules, where heat would not be permissable.	R. E. Moule, Dayton, Ohio. Assigned to General Motors Corporation. Reported in Science News Letter, 46 (Aug. 26, 1944) 130.
123.	Electric motor developed that has a speed of 120,000 revolutions per minute. See Development No. 119.	General Electric Corporation. Reported in "Science News", Science, 99 (Feb. 18, 1944) 12.
124.	Electric motor developed that has a speed of 120,000 revolutions per minute. See Developments No. 119, 123.	D. H. Ware, General Electric Corporation. Reported in Popular Science, 144 (June, 1944) 56H.
125.	Infra-red rays bake bread faster than oven.	F. B. Wells, Hackensack, New Jersey. Reported in Science Digest, 15 (April, 1944) 94.
126.	Reverse solar heating system cools house in summer.	A. B. Newton, Minneapolis. Reported in Science Digest, 15 (May, 1944) 93.

TABLE I, (CONTINUED)

Development	Source
127. Waster sawdust and shavings from sawmills used to make black opaque plastic of high tensile strength and high resistance to moisture. See Development No. 116.	Dr. R. A. Hardin, University of Oklahoma. Reported by Science Service. Also by Science Digest, 15 (May, 1944) 93.
128. Electric motor developed that has a speed of 120,000 revolutions per minute. See Developments No. 119, 123, 124.	D. H. Ware, General Electric Corporation. Reported in Science Digest, 15 (May, 1944) 94.
129. X-rays used to measure the thickness of white-hot steel sheets squeezed out between rollers at a speed of 20 miles per hour. See Development No. 121.	Dr. W. D. Coolidge, General Electric Corporation. Reported in Science Digest, 16 (July, 1944) 95.
130. Low-pressure extrusion of plastics for the manufacture of plastic thread possible by high-frequency radio wave heat.	P. Quinn, Society of the Plastics Industry. Reported in Science News Letter, 47 (Jan. 6, 1945) 5.
131. Exhaust-driven turbine pushes the air in new supercharger for automobiles.	C. E. Sorensen, Detroit, Michigan. Assigned to Ford Motor Company. Reported in Science News Letter, 47 (Jan. 13, 1945) 24.
132. Whirling jets of air under high pressure devised to keep windshield clear of water and ice.	W. M. Patterson, Detroit, Michigan. Reported in Science News Letter, 47 (Jan. 27, 1945) 56.

TABLE I, (CONTINUED)

	Development	Source
133.	New super-sensitive small electronic tube measures electricity equivalent to the light of a star many light years away.	W. A. Hayes, Westinghouse Electric and Manufacturing Company. Reported in Science News Letter, 47 (Feb. 10, 1945) 82.
134.	Pocket-size distillation apparatus for converting sea water into drinking water. Consists of plastic balloon to focus sunlight on black cellulose sponge. Sponge soaks up sea water, is heated and the evaporated water condenses on inner surface of balloon as fresh water where it is collected.	R. Delano, Locust Valley, New York. Assigned to Gallowhur Chemical Company. Reported in Science News Letter, 47 (Feb. 10, 1945) 88.
135.	X-ray camera that takes pictures in a millionth of a second to study behavior of bullets passing through bore of gun and as they strike an object.	Dr. C. W. Slack, Westinghouse Electric and Manufacturing Company. Reported in Science News Letter, 47 (Feb. 17, 1945) 103.
136.	Low-altitude night photographs may be taken without flash bombs by use of high-intensity multi-flash quartz photolamp.	Dr. H. Edgerton, Massachusetts Institute of Technology. Reported in Science News Letter, 47 (Feb. 24, 1945) 116.
137.	New dental device to replace tooth-drill operates on sand-blast principle. Uses aluminum oxide instead of sand as the abrasive.	Dr. R. B. Black, Corpus Christi, Texas. Reported in the Journal of the American Dental Association, (Aug, 1945) and also in Science News Letter, 48 (Aug. 11, 1945) 87.

TABLE I, (CONTINUED)

	Development	Source
138.	Passage of meteors recorded automatically and brilliance measured by apparatus which includes two photo-electric cells in a balanced circuit.	Dr. C. W. Cartlein and J. C. Logne, Cornell University. Reported in Science News Letter, 48 (Sept. 15, 1945) 169.
139.	The "Proximity or VT-Variable Fuse" fuze, a tiny radio set device in the nose of a projectile, causes it to explode when near the target.	Dr. M. A. Tune et al, Office of Scientific Research and Development. Reported in Science News Letter, 48 (Oct. 6, 1945) 214.
140.	Vast network of radio stations, "Loran- long range aid to navigation", locates pilot of ship or plane regardless of weather.	M. Eastham et al, Radiation Laboratory of Massachusetts Institute of Technology. "Loran Guides Pilots" by W. Davis, Science News Letter, 48 (Nov. 3, 1945) 275-276.
141.	Movement of "electric finger" around edge of template produces changes in electromagnetic fields which guide machine tools to cut replica of template.	S. H. Caldwell et al, Nilex-Sement-Pond Company, Hartford. Reported in Science News Letter, 48 (Dec. 8, 1945) 359.
142.	"Starlight tube", a new super-sensitive small electronic tube measures electricity equivalent to the light of a star many light years away. See Development No. 133.	W. A. Hayes, Westinghouse Electric and Manufacturing Company. Reported in "Science News", Science, 101 (Feb. 23, 1945) 10.

TABLE I, (CONTINUED)

	Development	Source
143.	"Solar-still", a pocket-size distillation apparatus for converting sea water into drinking water. See Development No. 134.	R. Delano, Locust Valley, New York. Assigned to Gallowhur Chemical Company. Reported in "Science News", Science, 101 (March 30, 1945) 10.
144.	Ball-point fountain pen has a six-month to two-year ink supply and will not leak at high altitudes or under water.	L. J. Biro, Argentine. Reported in Popular Science, 146 (Jan., 1945) 113.
145.	Pocket-size distillation apparatus for converting sea water into drinking water. See Developments No. 134, 143.	R. Delano, Locust Valley, New York. Assigned to Gallowhur Chemical Company. Reported in Popular Science, 146 (April, 1945) 121.
146.	The "Proximity Fuze", a tiny radio set device in the nose of a projectile, causes it to explode when near the target. See Development No. 139.	Dr. W. A. Tune, et al, Office of Scientific Research and Development. "Shells Hunt Targets by Radio" by D. Francis, Popular Science, 147 (Sept., 1945) 86-89, 230.
147.	Development of a process for transmitting television over ordinary telephone lines and a method of recording television programs for broadcasting.	H. E. Capehart, Packard Manufacturing Corporation. Reported in New York Herald Tribune and also in Science Digest, 17 (Jan., 1945) 93.

TABLE I, (CONCLUDED)

Development	Source
148. Process which introduces noise deliberately into long distance calls in order to eliminate "cross talk". This noise is not objectionable but it masks cross talk effectively.	R. S. Alford and R. C. Edson, West Orange, New Jersey. Reported in the New York Times and also in Science Digest, 17 (Jan., 1945) 94.
149. Low-altitude night photographs may be taken without flash bombs by use of high-intensity multi-flash quartz photolamp. See Development No. 136.	Dr. H. E. Edgerton, Massachusetts Institute of Technology. Reported in Science Digest, 18 (Aug., 1945) 75-76.
150. Passage of meteors recorded automatically and brilliance measured by apparatus which includes two photo-electric cells in a balanced circuit. See Development No. 138.	Dr. C. W. Gartlein and J. C. Logne, Cornell University. Reported in Science Digest, 18 (Nov., 1945) 64.
151. The "Proximity Fuze", a tiny radio set device in the nose of a projectile, causes it to explode when near the target. See Development No. 139, 146.	Dr. L. A. Tune, et al, Office of Scientific Research and Development. "Radio Shell that 'Sees' its Target" by W. Kaempffert. Science Digest, 18 (Dec., 1945) 89-91.

TABLE II

NUMBER OF DEVELOPMENTS IN PHYSICAL SCIENCE FOUND IN EACH PERIODICAL FOR EACH YEAR SURVEYED

Periodical	1941	1942	1943	1944	1945	Total
Science News Letter*	20	8	14	7	12	61
Science	25	5	4	1	2	37
Popular Science	9	6	1	1	3	20
Scientific Monthly	2	0	0	0	0	2
Science Digest	8	6	7	5	5	31
Total developments	64	25	26	14	22	151

*Table II is read thus: the periodical Science News Letter contained 20 developments in physical science in 1941, 8 in 1942, 14 in 1943, 7 in 1944, 12 in 1945, or a total of 61 developments in the five years.

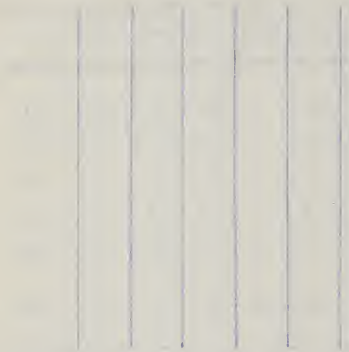

TABLE III

DEVELOPMENTS IN PHYSICAL SCIENCE
MENTIONED IN TWO OR MORE SOURCES

Number of Development	Science News Letter	Science	Scientific Monthly	Popular Science	Science Digest
1, 56*	x				x
2, 50, 58	x			x	x
10, 16, 27, 39, 54	xx	xx		x	
11, 30	x	x			
12, 29	x	x			
13, 31	x	x			
15, 28	x	x			
16, 60	x				x
19, 38	x	x			
20, 41, 62	x	x			x
44, 64		x			x
45, 80, 84, 115		x		x	xx
47, 63		x			x
65, 75, 87	x	x			x

*Table III is read thus: the development numbered 1 and 56 (in TABLE I) is mentioned in the following periodicals, Science News Letter, and Science Digest.

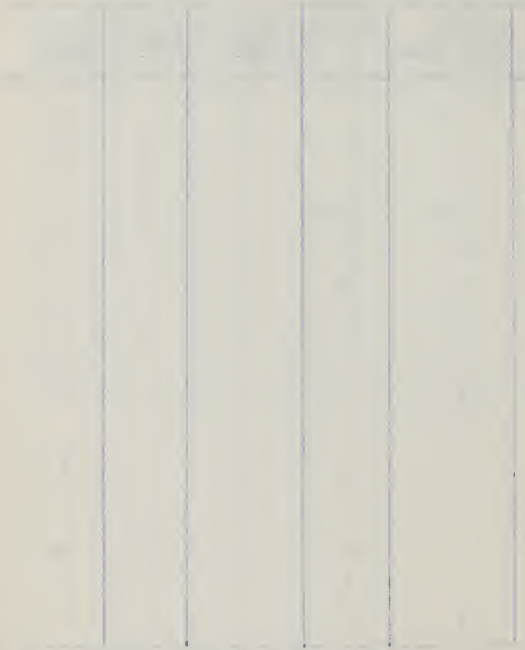

TABLE III, (CONCLUDED)

Number of Development	Science News Letter	Science	Scientific Monthly	Popular Science	Science Digest
69, 77	x	x			
66, 74	x	x			
78, 104		x		x	
82, 88				x	x
80, 108	x			x	
93, 109	x				x
98, 105	x	x			
102, 107	x	x			
103, 106	x	x			
100, 112	x				x
113, 120	x				x
119, 123, 124, 128	x	x		x	x
121, 129	x				x
133, 142	x	x			
134, 143, 145	x	x		x	
136, 149	x				x
138, 150	x				x
139, 146, 151	x			x	x
24, 81		x		x	

There was a total of thirty-three developments in physical science mentioned in two or more sources.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

RESTATEMENT OF THE PROBLEM

The problem of this paper was to survey the popular scientific periodicals for the period of World War II and to list the scientific developments which are concerned with the principles of physical science as formulated by Wise[1] (excluding those dealing specifically with chemistry).

SUMMARY OF THE TECHNIQUES EMPLOYED

Criteria for periodicals. Six criteria were established as a basis for the selection of periodicals to be analyzed for developments in physical science. Five periodicals were found to satisy the criteria.

Criteria for developments. Five criteria were established as a basis for the selection of developments in physical science from the periodicals. One hundred fifty-one developments were found to satisfy the criteria.

SUMMARY OF THE FINDINGS

The five periodicals contained a total of 151 developments in physical science. Of this total, 64 were published in 1941, 25 in 1942, 26 in 1943, 14 in 1944, and 22 in 1945.

[1] Loc. cit.

Seventy-four developments were found to be mentioned in more than one source. Three developments were mentioned as many as four times, while seventy-seven developments were found only once. It should be considered, however, that the developments mentioned in this investigation are only those that satisfied all of the criteria.

Of the five periodicals surveyed, Science News Letter contained the largest number of developments, sixty-one, while Scientific Monthly presented the fewest developments, two.

CONCLUSIONS

Lack of new principles. There were no published developments during the period surveyed and in the periodicals chosen that involved principles of physical science other than those previously formulated. Assuming that the periodicals chosen for the survey presented a comprehensive coverage of the scientific developments during World War II, a hypothetical conclusion would be that there have been little or no contributions to the basic concepts and principles previously established. This is not an attempt to minimize the efforts of the scientific investigators but merely to appraise their progress.

Importance of knowledge of scientific advances. All scientific advances, whether they be fundamental or not in

nature, are of extreme importance to educators. The science educators have a unique need for an up-to-date knowledge of developments in science. The developments provide vivid and immediate examples of the application in every day life of the fundamental principles. A knowledge of the bibliographical sources of developments, such as is provided by the present and similar papers, would enable the science educator to utilize this information to more efficiently teach an understanding of the fundamental concepts. He would be able to assign appropriate outside reading and provide valuable learning experiences for his pupils.

RECOMMENDATIONS

Need for similar studies. More studies of this type should be undertaken. Developments in the fields of chemistry, biology, and the medical sciences need to be surveyed for the educators in those fields. It is also necessary to keep studies of this nature up to date.

Developments related to principles. It is recommended that chronological lists of developments be rearranged and assigned to the underlying principles as an aid to educators. Time limitation prevented this being done in the present paper.

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